1756 AF

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

Applicant: Ramkumar SUBRAMANIAN, et al.

Title: TWO MASK PHOTORESIST EXPOSURE PATTERN FOR DENSE AND ISOLATED REGIONS

Appl. No.: 09/887,035

Filing Date: 06/25/2001

Examiner: K. Sagar

Art Unit: 1756

BRIEF ON APPEAL

Mail Stop Appeal Brief - Patents
Commissioner for Patents
PO Box 1450
Alexandria, Virginia 22313-1450

Sir:

This Appeal Brief is being filed in triplicate together with a check covering the appeal fee. Appellants hereby appeal the November 19, 2003 final rejection of claims 1-11, 13-20, 22-30 and 32 in the above-identified application to the Board of Patent Appeals and Interferences.

REAL PARTY IN INTEREST

The real party in interest is Advanced Micro Devices, Inc.

RELATED APPEALS AND INTERFERENCES

The undersigned is not aware of any related appeals or interferences.

STATUS OF CLAIMS

Claims 1-38 are pending. A copy of the pending claims is presented in the APPENDIX.

Claims 1-11, 13-20, 22-30 and 32 have been finally rejected under § 103(a) as being unpatentable over Pierrat (US Patent No. 6,218,098) in view of Irie (US Patent No. 6,337,162) further in view of Petersen (U.S. 2002/0001758) and further in view of Okamoto (U.S. Patent No. 6,309,800).

Claims 33-38 have been allowed. Claims 12, 21 and 31 have been objected to as being dependent on a rejected base claim, but would be allowable if rewritten in independent form.

STATUS OF AMENDMENTS

There are no amendments after final rejection.

SUMMARY OF INVENTION

In accordance with one preferred aspect of the present invention, there is provided a method of making a plurality of features in a first layer 21. The method comprises forming a photoresist layer 23 over the first layer 21 and exposing dense regions 25A, 25B, 25C in the photoresist layer through a first mask 29 under a first set of illumination conditions (paragraph [0022] and Figure 4A of the application). The method further comprises exposing at least one isolated region 27A in the photoresist layer 23 through a second mask 30 different from the first mask 29 under a second set of illumination conditions different from the first set of illumination conditions (paragraph [0023] and Figure 4B of the application). The method further comprises patterning the exposed photoresist layer 23 and patterning the first layer 21 using the patterned photoresist layer 23 as a mask (paragraphs [0024] and [0025] and Figures 4C and 4D of the application).

ISSUES

The issue is whether claims 1-11, 13-20, 22-30 and 32 are obvious over Pierrat in view of Irie further in view of Petersen and further in view of Okamoto.

GROUPING OF CLAIMS

I. Claims 1-11 stand or fall together.

II. Claims 14-20 stand or fall together.

III. Claims 23-30 stand or fall together.

IV. Claim 12 stands or falls together.

V. Claim 21 stands or falls together.

VI. Claim 31 stands or falls together.

VII. Claims 33-38 stand or fall together.

VIII. Claims 13, 22 and 32 stand or fall together.

SUMMARY OF THE ARGUMENT

Independent claims 1, 14 and 23 recite exposing the same photoresist layer through two different masks, where dense features are exposed through one mask and the isolated features are exposed through another mask. This feature is not taught or suggested by any of the four references applied in the § 103(a) rejection, either alone or in combination. Thus, even if there was motivation to combine the four references, the combination would still not contain all limitations of the independent claims of the present application.

There is no motivation to combine the applied references to arrive at the claimed invention. Pierrat teaches that the use of reverse tone masks to expose the same photoresist layer reduces the proximity effect. Both the dense and isolated regions are exposed through the first and through the second masks. Irie and Petersen teach different masks, but do not teach that these masks may be used to expose the same photoresist layer. Thus, there is no motivation to substitute the reverse tone masks of Pierrat with the dense and isolated feature masks of Irie as modified by Petersen.

The combination proposed in the Office Action would change the principle of operation of the method of Pierrat and make it unsuitable for its intended purpose. Such a combination is not permitted. MPEP § 2143.01.

ARGUMENT

Appellants respectfully submit that the four reference rejection is based on hindsight reconstruction and that there is no motivation to combine the four references to arrive at the claimed invention. Even if there was motivation to combine the prior art references, the resulting combination would still not teach or suggest all claim limitations.

The independent claims of the present application recite exposing the same photoresist layer through two different masks, where the dense features are exposed through one mask and the isolated features are exposed through another mask. This feature is not taught or suggested by any of the four references, alone or in combination.

A. Pierrat

Pierrat does not teach grouping dense and isolated features on the different masks and exposing the dense and isolated features in the same photoresist using different masks. Pierrat teaches to expose the same photoresist layer twice through the same mask using a different axis of exposure to decrease the proximity effect (see Figures 5 and 6 and col. 4, lines 29-50 and col. 6, lines 21-64 of Pierrat). During each exposure, both the dense and isolated features are exposed in the photoresist layer.

Pierrat also teaches to expose the photoresist layer through two different reverse tone masks in Figures 7-9 and in col. 7, line 50 to col. 8, line 30. The photoresist layer is first exposed through the mask of Figure 2 of Pierrat followed by the exposure through a reverse tone mask to decrease the proximity effect. However, both the dense and isolated regions in the photoresist layer are exposed through each mask. Thus, in contrast to the statement on page 4, line 10 of the Final Office Action, Pierrat does not teach separation of dense and isolated features, while the independent claims of the present application require separate exposures of dense and isolated features through different masks.

B. Irie

Irie does not teach or suggest exposing the same photoresist layer using two different masks. Irie's disclosure is directed mainly to a method of making a photomask rather than a method of making a semiconductor device. For example, Irie teaches forming a glass reticle

(i.e., photomask) 34 that contains a metal master pattern 27 on one surface (see Figure 1 of Irie). Irie teaches to form dense patterns on the master pattern 27 on one reticle, Ra, and isolated patterns on another reticle, Rb. The exposure conditions for forming the different reticles, Ra and Rb may be different (see col. 22, lines 23-35). Thus, Irie teaches to form two different reticles, Ra and Rb, with one reticle containing dense features and the other device containing isolated features. A different photoresist layer is used to form the master pattern 27 on each reticle Ra and Rb. Irie does not teach to use both reticles Ra and Rb to sequentially expose the same photoresist layer over a semiconductor device or substrate. For example, the completed reticles Ra and Rb may be used to expose different photoresist layers formed over the same or different semiconductor device or substrate.

C. Petersen

Petersen also does not teach or suggest to use two different masks to expose the same photoresist layer. Petersen teaches that process exposure windows for different phase shift masks may be different. However, Petersen does not teach or suggest that these two masks are used to expose the same photoresist layer. For example, these masks may be used to expose different photoresist layers.

D. Okamoto

Okamoto was relied on in the Office Action for the teaching of a multilevel device. Thus, Okamoto was not relied on for a teaching to use two different masks to expose the same photoresist layer.

E. No motivation to combine

There is no motivation to combine the applied references to arrive at the claimed invention. Pierrat teaches the use of reverse tone masks to expose the same photoresist layer reduces the proximity effect. Both the dense and isolated regions are exposed through the first and through the second masks. Irie and Petersen teach different masks, but do not teach that these masks may be used to expose the same photoresist layer. Thus, there is no motivation to substitute the masks of Pierrat with the dense and isolated feature masks of Irie as modified by Petersen.

The Final Office Action on page 4 states that the motivation to combine is that the three references teach the separation of dense and isolated features and exposure with optimal illuminating conditions and that Irie and Petersen teach separating features on two or more masks for multiple exposures for optimizing exposure conditions and because there may be no common focus, respectively. However, none of these references provides motivation for separating dense and isolated regions in the same photoresist, as recited in the independent claims of the present application.

Pierrat does not teach to separate dense and isolated regions in the same photoresist since both dense and isolated regions are exposed through each mask. Likewise, Irie and Petersen do not teach to separate dense and isolated regions in the same photoresist since Irie and Petersen do not teach to expose the same photoresist through different masks with dense and isolated features.

Furthermore, Irie and Petersen do not necessarily teach to separate dense and isolated features on different masks for "multiple exposures" as noted on page 4 of the Final Office Action. As discussed above, the separate masks may be used to single expose different photoresist layers to form dense features in one photoresist layer and isolated features in another photoresist layer.

The Final Office Action also notes on page 4 that Irie teaches that separation on two or more masks facilitates optimizing exposure conditions. However, Irie teaches that that separation of dense and isolated features on two or more masks facilitates optimizing exposure conditions while forming the masks or reticles themselves. Irie does not teach that such separation is advantageous for exposing a photoresist layer over a semiconductor device or substrate, such as while forming a semiconductor device of Pierrat. Thus, this is an additional reason why there is no motivation to combine Pierrat and Irie.

F. The proposed combination would impermissibly modify Pierrat

Furthermore, the combination proposed in the Final Office Action would change the principle of operation of the method of Pierrat and make it unsuitable for its intended purpose. Such a combination is not permitted. MPEP 2143.01. The two mask method of Figures 7-9 of Pierrat operates on the principle of exposing both dense and isolated features

in a photoresist layer through each mask, but with the tone of each mask being reversed. The purpose of this method is to reduce the proximity effect. If the reverse tone masks of Pierrat were replaced with the dense and isolated feature masks of Irie and Petersen, then the principle of operation of the method of Pierrat would be changed. Furthermore, this may make the method of Pierrat unsuitable for reducing the proximity effect.

G. The combination of references does not teach or suggest all claim limitations

Even if there was motivation to combine these four references, the combination would still not contain all limitations of the independent claims of the present application. None of the four references teaches exposing dense and isolation features in the same photoresist layer through different masks. To establish a prima facie case of obviousness, the Final Office Action must demonstrate that each claim limitation is taught in one or more references. In this case, the claim limitation reciting exposing dense and isolated regions in the same photoresist layer using different masks is not disclosed in any of the applied references. Therefore, a prima facie case of obviousness was not established.

H. Response to comments in paragraph 6 of the final Office Action

The examiner asserted on page 6, first full paragraph of the Final Office Action that appellants' arguments are improperly directed against the references individually, where the rejection is based on a combination of references. Appellants respectfully disagree.

Arguments that are improperly directed against the references individually usually take the following form. Claim reciting limitations X+Y is rejected over reference A teaching X in view of reference B teaching Y. Thus, each limitation of the claim is taught in at least one applied reference. In response, applicant improperly argues that reference A does not teach Y while reference B does not teach X.

In contrast, in the present application, the independent claims recite at least one limitation (exposing the same photoresist layer through two different masks, where dense features are exposed through one mask and the isolated features are exposed through another mask) which is not taught in any of the four applied references. Appellants' previous arguments describe each applied reference and note that this claim limitation is not taught in any of the four references. Appellants believe that these arguments are not a case of

arguments that are improperly directed against the references individually, where the rejection is based on a combination of references.

The examiner also asserted on page 6, last line to page 7, first line that "the test is what the combined teachings of the references would have suggested to one of ordinary skill in the art." Appellants respectfully point out that the combined teachings of the applied references would not have suggested exposing the same photoresist layer through two different masks, where dense features are exposed through one mask and the isolated features are exposed through another mask, without improper hindsight reconstruction, because none of the applied references teach this claim limitation.

The examiner asserts on the bottom of the first full paragraph on page 6 that Irie teaches exposing multiple masks on a device substrate, as provided in col. 9, line 47 of Irie. The examiner also notes on page 3, second full paragraph of the Final Office Action that Irie teaches stitching patterns during overlay exposures through multiple masks in column 5, line 56 to col. 6, line 23 of Irie.

The examiner relies on column 22, lines 23-36 of Irie for the teaching of making different masks with dense and isolated patterns. Column 22, lines 23-36 is part of the method of the first embodiment of Irie, which is described in column 16, line 50 to column 34, line 23.

Appellants do not disagree that the masks of Irie are eventually used to expose photoresist layers on a device substrate. However, Appellants disagree that there is any teaching or suggestion in Irie that the two different masks Ra and Rb described in column 22, lines 23-36 of Irie may be used to expose the same photoresist layer on the same device substrate. Column 9, line 47 of Irie does not teach or suggest that the two different masks Ra and Rb described in column 22, lines 23-36 of Irie may be used to expose the same photoresist layer on the same device substrate. Col. 9, line 47 of Irie merely teaches to use a working mask 34 to expose a device substrate.

Likewise, the stitching method described in column 5, line 56 to col. 6, line 23 is believed to be part of a different embodiment than the method described in column 22, lines 20-36 of Irie. Appellants believe that the stitching method is also described in the third

embodiment of Irie, which begins on column 35 of Irie, which is different from the first embodiment which contains col. 22, lines 23-36. The stitching method is used to divide an enlarged pattern into smaller patterns on a plurality of masks (col. 5, lines 55-59 of Irie). The stitching method is not used to separately expose dense and isolated features. Furthermore, there is no motivation to use the masks Ra and Rb of column 22, lines 23-36 of Irie in a stitching method of columns 5 and 6 because the stitching method requires overlapping exposure of one area with a part of another area, as provided in column 6, lines 17-23 of Irie. Thus, if the dense and isolated features are both located in the non-overlapped areas, then the stitching method of Irie would not be suitable to expose dense and isolated areas in the same photoresist through different masks.

Page 6, last two lines of the first full paragraph of the Final Office Action states that the argument that the masks Ra and Rb of Irie may be used to expose different layers or different substrate is spurious. Appellants respectfully disagree.

Irie does not teach how the masks Ra and Rb described in column 22 of Irie are used to expose a device substrate. Thus, Irie does not inherently teach or suggest that masks Ra and Rb must be used to expose the same photoresist layer, because these masks Ra and Rb may be used to expose different photoresist layers that are formed over the same or different substrates.

At the top of page 7 of the Final Office Action, the examiner states that a "skilled artisan would have immediately recognized the method of combining Pierrat's two-mask method with Irie's separation of features on two masks." Appellants respectfully disagree.

A skilled artisan would not combine Pierrat's two-mask method with Irie's separation of features on two masks without resorting to impermissible hindsight reconstruction by using the present specification as a template. First, Irie provides no motivation or suggestion that the masks Ra and Rb may be used to expose the same photoresist layer. Second, Pierrat teaches that both dense and isolated features in the same photoresist are exposed through each mask. Thus, the masks Ra and Rb of Irie are unsuitable for carrying out the exposure method of Pierrat because each of the masks does not expose both dense and isolated features, as required by Pierrat. As discussed above, Pierrat cannot be modified to selectively expose

only dense or isolated features through each mask because it would impermissibly change the principle of operation of the method of Pierrat.

I. Reasons for claim grouping

Independent claim 14 recites additional limitations compared to independent claim 1, such as that the different illumination condition comprises a different focus. Thus, claim 14 is separately patentable from claim 1 because it further distinguishes column 22, lines 23-36 of Irie.

Independent claim 23 recites etching an insulating layer and filling a conductive material in the openings. These limitations further distinguish Irie.

Claims 12, 21, 31 and 33-38 comprise separate groups because they comprise allowed claims with different limitations.

Dependent claims 13, 22 and 32 are product by process claims. The examiner asserted that these claims have a broader scope than the independent claims 1, 14 and 23, respectively, from which they depend. Thus, these claims 13, 22 and 32 are grouped separately because if the examiner's claim interpretation is adopted, then claims 1, 14 and 23 are separately patentable from claims 13, 22 and 32 due to their process limitations, such as exposing dense and isolation features in the same photoresist layer through different masks.

CONCLUSION

Accordingly, Appellants respectfully solicit the Honorable Board of Patent Appeals and Interferences to reverse the rejection of the pending claims and pass this application on to allowance.

Respectfully submitted,

1/5/04

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This Appeal Brief is being filed in triplicate together with a check in the amount of $320 (large entity) covering the appeal fee. If this fee is deemed to be insufficient, authorization is hereby given to charge any deficiency (or credit any balance) to the undersigned deposit account 19-0741.

APPENDIX

1. A method of making plurality of features in a first layer, comprising:

forming a photoresist layer over the first layer;

exposing dense regions in the photoresist layer through a first mask under a first set of illumination conditions;

exposing at least one isolated region in the photoresist layer through a second mask different from the first mask under a second set of illumination conditions different from the first set of illumination conditions;

patterning the exposed photoresist layer; and

patterning the first layer using the patterned photoresist layer as a mask.

2. The method of claim 1, wherein patterning the photoresist layer comprises removing the exposed dense and isolated regions in the photoresist layer.

3. The method of claim 1, wherein patterning the photoresist layer comprises removing the unexposed regions in the photoresist layer without removing the exposed dense and isolated regions in the photoresist layer.

4. The method of claim 1, wherein:

the first layer comprises an insulating layer; and

patterning the first layer comprises providing an etching gas or an etching liquid to the first layer through openings in the patterned photoresist layer to form a plurality of dense and isolated openings in the first layer.

5. The method of claim 1, wherein:

the first layer comprises a semiconductor or a conductive layer; and

patterning the first layer comprises providing an etching gas or an etching liquid to the first layer through openings in the patterned photoresist layer to form a plurality of features in the first layer.

6. The method of claim 1, wherein the first set of illumination conditions and the second set of illumination conditions differ by at least one of focus, partial coherence, numerical aperture width, and illumination type.

7. The method of claim 6, wherein the first set of illumination conditions has a different focus than the second set of illumination conditions.

8. The method of claim 6, further comprising:

selecting the first set of illumination conditions that are optimized to expose dense regions in the photoresist layer; and

selecting the second set of illumination conditions that are optimized to expose isolated regions in the photoresist layer.

9. The method of claim 8, wherein the dense exposed regions are separated by 500 nm or less from a nearest other exposed region and the isolated exposed regions are separated by more than 500 nm from a nearest other exposed region.

10. The method of claim 8, wherein the dense exposed regions are separated by 300 nm or less from a nearest other exposed region and the isolated exposed regions are separated by 1 micron or more from a nearest other exposed region.

11. The method of claim 10, further comprising exposing semi-dense regions separated by 301 to 999 nm in the photoresist layer through a third mask different from the first and the second masks under a third set of illumination conditions different from the first and the second sets of illumination conditions.

12. The method of claim 1, wherein values of exposure dose and defocus used to expose the dense regions or the at least one isolated region are located in a respective process window outside an overlap region between the respective process windows.

13. A solid state device made by the process of claim 1.

14. A method of making a semiconductor device, comprising:

forming a first layer of the semiconductor device;

forming a photoresist layer over the first layer;

exposing dense regions in the photoresist layer through a first mask using a first focus;

exposing isolated regions in the photoresist layer through a second mask different from the first mask using a second focus different from the first focus;

removing the exposed dense and isolated regions in the photoresist layer to form a patterned photoresist layer; and

etching the first layer using the patterned photoresist layer as a mask.

15. The method of claim 14, wherein:

the first layer comprises an insulating layer; and

etching the first layer comprises providing an etching gas or an etching liquid to the first layer through openings in the patterned photoresist layer to form a plurality of dense and isolated openings in the first layer.

16. The method of claim 14, wherein:

the first layer comprises a semiconductor or a conductive layer; and

etching the first layer comprises providing an etching gas or an etching liquid to the first layer through openings in the patterned photoresist layer to form a plurality of features in the first layer.

17. The method of claim 14, further comprising:

selecting the first focus which is optimized to expose dense regions in the photoresist layer; and

selecting the second focus which is optimized to expose isolated regions in the photoresist layer.

18. The method of claim 14, wherein the dense exposed regions are separated by 500 nm or less from a nearest other exposed region and the isolated exposed regions are separated by more than 500 nm from a nearest other exposed region.

19. The method of claim 14, wherein the dense exposed regions are separated by 300 nm or less from a nearest other exposed region and the isolated exposed regions are separated by 1 micron or more from a nearest other exposed region.

20. The method of claim 18, further comprising exposing semi-dense regions separated by 301 to 999 nm in the photoresist layer through a third mask different from the first and the second masks using a third focus different from the first and the second focus.

21. The method of claim 14, wherein values of exposure dose and defocus used to expose the dense regions or the isolated regions are located in a respective process window outside an overlap region between the respective process windows.

22. A semiconductor device made by the process of claim 14.

23. A method of making a semiconductor device, comprising:

forming at least one semiconductor device on a substrate;

forming a first insulating layer over the semiconductor device;

forming a photoresist layer over the first insulating layer;

exposing dense regions in the photoresist layer through a first mask using a first focus;

exposing isolated regions in the photoresist layer through a second mask different from the first mask using a second focus different from the first focus;

removing the exposed dense and isolated regions in the photoresist layer to form dense and isolated openings in the photoresist layer;

providing an etching gas or an etching liquid to the first insulating layer through the dense and the isolated openings in the photoresist layer to form a plurality of dense and isolated openings in the first insulating layer; and

forming a conductive material in the dense and the isolated openings.

24. The method of claim 23, further comprising:

selecting the first focus which is optimized to expose dense regions in the photoresist layer; and

selecting the second focus which is optimized to expose isolated regions in the photoresist layer.

25. The method of claim 23, wherein:

the dense exposed regions are separated by 500 nm or less from a nearest other exposed region;

the isolated exposed regions are separated by more than 500 nm from a nearest other exposed region;

the dense openings in the first insulating layer are separated by 500 nm or less from a nearest other opening; and

the isolated openings in the first insulating layer are separated by more than 500 nm from a nearest other opening.

26. The method of claim 23, wherein the dense exposed regions are separated by 300 nm or less from a nearest other exposed region and the isolated exposed regions are separated by 1 micron or more from a nearest other exposed region.

27. The method of claim 26, further comprising exposing semi-dense regions separated by 301 to 999 nm in the photoresist layer through a third mask different from the first and the second masks using a third focus different from the first and the second focus.

28. The method of claim 23, wherein:

the substrate comprises a semiconductor, a glass or a plastic material;

the first insulating layer comprises at least one of silicon oxide, silicon nitride, silicon oxynitride, fluorinated silicon oxide, aluminum oxide, tantalum oxide, BPSG, PSG, BSG or spin on glass;

the conductive material comprises at least one of polysilicon, aluminum, copper, tungsten, titanium, titanium nitride or metal silicide; and

the at least one semiconductor device comprises at least one of a MOSFET, a MESFET, a bipolar transistor, a capacitor or a resistor.

29. The method of claim 23, wherein exposing the dense regions occurs before exposing the isolated regions.

30. The method of claim 23, wherein exposing the dense regions occurs after exposing the isolated regions.

31. The method of claim 23, wherein values of exposure dose and defocus used to expose the dense regions or the isolated regions are located in a respective process window outside an overlap region between the respective process windows.

32. A semiconductor device made by the method of claim 23.

33. A method of making a plurality of features in a first layer, comprising:

forming a photoresist layer over the first layer;

exposing dense regions in the photoresist layer through a first mask under a first set of illumination conditions;

exposing at least one isolated region in the photoresist layer through a second mask different from the first mask under a second set of illumination conditions different from the first set of illumination conditions;

patterning the exposed photoresist layer; and

patterning the first layer using the patterned photoresist layer as a mask;

wherein:

values of exposure dose and defocus used to expose the dense regions or the at least one isolated region are located in a respective process window outside an overlap region between the respective process windows; or

the first set of illumination conditions and the second set of illumination conditions have a different focus.

34. The method of claim 33, wherein patterning the photoresist layer comprises removing the exposed dense and isolated regions in the photoresist layer.

35. The method of claim 33, wherein patterning the photoresist layer comprises removing the unexposed regions in the photoresist layer without removing the exposed dense and isolated regions in the photoresist layer.

36. The method of claim 33, wherein values of exposure dose and defocus used to expose the dense regions or the at least one isolated region are located in a respective process window outside an overlap region between the respective process windows.

37. The method of claim 33, wherein the first set of illumination conditions and the second set of illumination conditions have a different focus.

38. The method of claim 33, wherein:

only dense regions in the photoresist layer are exposed through the first mask; and

only isolated regions in the photoresist layer are exposed through the second mask.

NOTICE OF FEE DUE

61

DATE: 01-06-04

TO: Af

FROM: Office of Initial Patent Examination

SUBJECT: Fee Due

APPLICATION NUMBER: 09/887,035

A fee is due for the attached document submitted to the U. S. Patent and Trademark Office for the following reason. Please check the application for the appropriate authorization to charge a deposit account. If an authorization is present, please charge the appropriate fee. If an authorization is not present, notify the applicant of the fee deficiency.

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If you have any questions, please contact Cynthia Streater at 703-306-5430 or Eleanor Kurtz at 703-308-3642.

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